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SEMINAR ON THE WELDING OF PLASTICS

-USSR-

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FOREWORD

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SEMINAR ON THE WELDING OF PLASTICS

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(Based on materials from the seminar "Welding of Plastics" held in the Moscow House of Scientific and Technical Propaganda imeni F. E. Dzerzhinskiy in June 1960.)

The plastics industry is developing at the present time at an accelerating pace. Existing methods of re-processing plastics into parts and other articles are already inadequate, in spite of the improvement and automatization of pressing methods, casting under pressure, jet spraying, vacuum forming, gas-flame spraying, and others. One promising plastics processing method is the welding of plastics. Even at present, among various methods of plastics processing the welding of plastics accounts for about 20 %. Plastics welding, as in metals welding, must occupy a leading place in industrial technology.

In addition to the basic methods of plastics welding (high-frequency, thermo-contact, and gas-flame) there are already being applied new welding methods -- radiational, ultrasonic, friction welding, and others. Each of these welding methods is employed in dependence on the physico-mechanical properties of the welded material, the construction of the article, the necessary production equipment, and so on. Welding is employed with articles of thermal layers in the form of sheets, films, and construction parts (pipes, girders, corner brackets, and so on). Welded plastic items are utilized in almost all fields of industry and in the national economy.

At the seminar "The Welding of Plastics", which was organized by the section on welding of the Moscow House of

Scientific and Technical Propaganda imeni F. E. Dzershinskiy, the newest welding methods, along with the appropriate equipment, were studied. The work experience of plants employing plastics welding was also elaborated on, and the results of scientific research work carried on in the NIIPM (Nauchno-issledovatel'skiy institut plasticheskikh mass -- Scientific Research Institute on Plastics) and in other NII (Scientific Research Institutes) and KB (Konstruktorskiye byura -- Design Offices).

Opening the seminar, A. Ya. Kazhdan reported on the technical characteristics of thermoplastics and the methods existing for welding.

In a report by N. A. Grishin -- "Weldability of thermolayers" the interesting work carried out in conjunction S. S. Voyutskiy and M. M. Gudimovyy was described, as dealing with the clarification of the nature of the welding of rigid thermolayers. Although the techniques of polymer welding are being vigorously developed, the theory of this process has hardly been worked on. The authors explained the nature of the phenomenon of rigid thermolayer welding from the viewpoint of diffusion theory. According to this theory the self-adhesion of material is conditioned on the diffusion of portions of molecules from one volume to another and the formation of stable bonds. Diffusion theory proceeds from the most characteristic properties of polymers -- long-chain structure and high flexibility of molecules, which is dependent on the intensive thermal motion of some of their links. Reduced weldability of fluorolayers and its dependence on the duration of the process is explained by the mobility of some links only. Consequently, from the viewpoint of this theory all factors operating to facilitate the mobility of molecules or parts of molecules must positively affect the weldability; on the other hand, factors hindering mobility must impair the weldability. This general conclusion is confirmed by experimental data.

I. G. Fedorov reported on the equipment and technology of plastics welding by means of high-frequency current. High-frequency welding is widely employed in working with polyvinylchloride plastics. Its chief advantages lie in the rapid heating, the independence from the heat conductivity and gage of the welded material, the potential for automatization of the process, the high quality of welded assemblies, and the dimensional reproducibility of the welding results. A frequency range of 20-70 megahertz is employed for the welding of thermolayers. This method can be used in welding vinyl-layers (the seam can be of the butt-end type, with cover plate, and overlap); preliminary preparation of the seam for welding production is not required. Tubes of sheet vinyl can also

be successfully welded. In the Leningrad Plant imeni Karl Marx high-frequency welding is employed textile machine parts of masticated rubber; in the Okhtinskiy Chemical Complex -- on the welding of reinforced parts. It is established that the capital expenditure incurred upon the introduction of high-frequency welding equipment is recovered with three to five months. A conditional annual economy upon the utilization of the production techniques stands at 100-200 thousand rubles per one kilowatt of high-frequency power. In the future high-frequency welding will be employed for the welding of polyamidic, tri-acetate, and polycaprolactamic films, fluroplastics-3, polyethylene with fillers, and others.

Z. A. Kogan shared with the seminar the testing of welding performance for polyvinylchloride films on the VChS-0.4 and the VChS-0.2 machines. Hermetic jacketing made of films of plastic materials is employed in the packing of industrial equipment destined for tropical lands, for passage by sea, and for protracted storage. This replaces the laborious method of packing in multi-layer paper containers or in soldered casings of sheet metal with added protective coating. The so-called impulse welding is employed for the welding of films having a thickness of from 0.10-0.12 mm, whereas high-frequency current welding is employed for films of thickness greater than 0.15 mm. The Scientific Research Institute for High-Frequency Current has developed and produced two types of apparatus for the welding of polyvinylchloride films: the stationary type VChS-0.4 and the mobile type with manually-operated vise VChS-0.2. These machines are successfully operating in the "Dynamo" Plant in Moscow, where they have been responsible for an annual savings of about 100,000 rubles.

V. S. Sarychev discussed the experience of work in the application of high-frequency welding in the manufacture of overalls from polyvinylchloride, polyethylenic, and fluoropolymer films. The welding of the overall parts is carried out on a special machine. Following are some basic characteristics of this machine: generator of the LGD-1 type (operating frequency -- 25-30 megahertz, power -- 1 kilowatt); the welding time is dependent on the area of the welding seam and the film thickness -- from 0.5 to 50 seconds. The welding of seams may be done both horizontally and vertically. The seams can be linear or extremely configurated. It is possible to weld deteriorated sections and to weld on to polyvinylchloride masticated-rubber, cotton-paper tapes, elastic bands, and so on.

V. V. Chudinov discussed the high-frequency welding of protective coverings from polyvinylchloride

masticated rubber on the areas of production premises. Protective coatings on the areas of a number of production premises must be hermetic, smooth, adequately strong mechnically, of high resistance to attacking media, and possessing good sorption-desorption properties. Polyvinylchloride masticated rubber 2-4 mm in thickness qualifies as such material. The main obstacle to its wide application is the absence of a method of binding the individual layers of this material to each other. There has now been developed a method of welding by high-frequency current, in which the welding electrodes are consumed from one side of the welded sheets, which allows for a continuous welding on to the area. A special pad of non-thermoplastic film (cellophane) is employed for the making of the seam, resulting in a smooth and lustrous joining. The strength of the seam, when working at a rate of 0.5-1.0 meter/minute, is 80-85% of the strength of the material. The following types of equipment have been developed for welding from sheets and rolls large coverings hundreds of square meters in area: the portable SPP machine with semi-automatic control of the welding process; a stationary machine for the preliminary welding of sheets of masticated rubber into rolls; the manually-operated SPPR devices for the welding of linear seams on a horizontal surface; a number of devices for the welding of flanges along walls, around pipes coming out of the ground, and so on. A special interest lies in the welding of thick sheets of masticated rubber into the lining of large-capacity chemical apparatus.

A. V. Mordvintsev reported on equipment and methods of plastics welding by means of ultrasonics. Welding plastics by ultrasonics is a new method of joining plastics. It recalls to one's mind the contact welding of metals and is based on using the heat generated in the welded surface and in the mechanical action of very high-frequency oscillations on the assembly materials. The advantages of welding by ultrasonics consist in the following:

1. Maximal initial heating takes place on the surfaces to be welded, thus excluding deep heating of the plastics.

2. Under the correctly chosen conditions there is no excess heating of the surfaces to which the ultrasonics is applied.

3. The concentration of heat on the surfaces to be welded ensures high productivity for the process.

4. The ultrasonic methods enables welding to be carried out on parts of various forms, in difficultly accessible places, and for those kinds of joinings ordinary methods

are not successful with.

5. The welding process is simplified as a result of the supply of energy to only one of the surfaces to be welded and owing to the opportunity of introducing the ultrasonic oscillations at a considerable distance from the place of welding.

6. Welding by ultrasonics is easily automatized.

Machines have already been constructed for ultrasonic spot, pressing, and seam welding of plastics; welding instruments have been created for welding by current, short seams, and by compression. Experience has shown that almost all thermoplastic plastics can be welded by ultrasonics. Welding of several films 10 mm in thickness has already been achieved. Overlap and tee-shaped joins have been accomplished. The strength of welded assemblies is quite high.

Ultrasonic welding has without a doubt found wide application.

A report by Bogdashevskiy was devoted especially to the thermal calculations in ultrasonic welding and the strength of the welded assemblies. All polymeric materials are heated by ultrasonic oscillations owing to absorption of the energy of the oscillations. The rate of temperature increase and also the maximal temperatures, arising at the welding site, are determined by the structure and the properties of the material. Materials which do not make a transition into the viscous-flowing state cannot be welded, even though when ultrasonic oscillations are applied to them, they are heated up to the decomposition temperature (for example, polytetrafluoroethylene). At the present time machines have already been produced for the welding by ultrasonics of polymeric materials. Further investigation should be directed toward finding more economical and more effective welding methods, toward the development of welding procedures using preheating of materials to be welded, toward the development of production layouts for the automatic control of generator frequency in accordance with a resonant frequency system, toward the search for holding methods in the welding of large-scale articles.

N. A. Grishin dwelt on the thermoimpulse welding of plastics. Thermoimpulse welding is a variety of contact welding with a heater. However, in place of massive heaters with large heat capacities, fine metallic strips are used. Upon the transmission of the electrical impulse these strips are heated for a fraction of a second to the melting temperature of the thermoplastics. Cooling follows the heating. During this period the direction of the heat flow is reversed: the residual heat from the welded

seam through the strips, which cool very rapidly due to low heat capacity. The heating involved in the welding of fine films may be one-sided, which serves to simplify the layout. In the case of films with thickness greater than 0.15 mm it is necessary to use bilateral heating. In thérmo-impulse welding the material does not adhere to the heating elements, that is, a portion of the heater operates after the cooling of the films.

D. V. Mondrus demonstrated an apparatus for welding by means of heat from resistance elements. O. A. Kotovshchikov discussed the welding of fluoroplastics. He reported that equipment has been developed for the mechanized welding of fluoroplastic films with thicknesses up to 200 microns, and for films of the fiber-stiffened type with thicknesses up to 300-350 microns. The welding is accomplished by means of a bilateral contact of the material to be welded with the heating elements. A continuous welding of fluoroplastic films is achieved on the MSP-4 machine. The material to be welded is moved parallelwise by endless bands, which also serve as heat conductors. The welding of short seams is done on equipment which provides a bilateral heating of the welded material. The welding of films of fluoroplastics-4 is assured only upon prolonged passage through heater area at temperatures of 350-380°. The speed of welding fluoroplastics-4 films having a thickness 40-50 microns is 14-16 meter/hour; films of a 100-micron thickness are welded at a speed of 8-10 meter/hour, films of a 200-micron thickness -- at 4-5 meter/hour. The time of passage in welding on the impulse equipment is 4-8 minutes. A maximal strength of 0.2-0.3 kilograms/cm^2 for the welded parts is obtained. The tearing strength of the welded parts made of fluoroplastics-4 films under optimal conditions stands at 70-80 % of the basic material. The strength of the welded parts depends on the cooling conditions of the seam material and the seam area after welding. The welding of fluorlon (fluoro-containing co-polymers) 60-120 microns in thickness is achieved by a one-sided heating of the material being welded by heat conductors. In welding by gaseous heat conductors the speed of the process does not exceed 0.5 meter/minute. Welding by heating element without pads is done at a speed of 1.5-2.5 meters/minute for the process. Pre-treatment of the film by fluorlonic varnish or solvent improves the weldability of the material. Film made of copolymer-62 having a thickness 40-80 microns is welded only by use of bilateral heating of the material during a period of prolonged passage (not less than 1-2 minutes). The strength upon tearing stands as 30-40% of the strength of the basic

material. In welding fiber-film materials (fluorlonic film stiffened with fibers) only bilateral heating can be used. G. S. Vashin shared with the seminar the experience of the work at the Derbenevskiy Chemical Plant on the production of welded structures made from plastics. I. A. Nemkovskiy elaborated on apparatus for gas-flame welding of plastics.

The seminar participants adopted recommendations for the introduction of plastics welding into industry.

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